FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: **(H)01PH0405USP**

U S APPLICATION NO. (IF KNOWN, SEE 37 CFR): **10/018980**

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/02017	**June 27, 2000**	**June 28, 1999**

TITLE OF INVENTION

Circuit for switching on and operating units connected in series with regard to their power supply voltage in a control and data transmission system

APPLICANT(S) FOR DO/EO/US

Grewe et al

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). UNEXECUTED
10. ☒ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☒ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☒ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

General Authoruzation to Charge Fees
2 Sheets of drawings

Received PCT 18 DEC 2001

U.S. APPLICATION NO (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
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24. The following fees are submitted:.	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	22 - 20 =	2	x $18.00	**$36.00**	
Independent claims	1 - 3 =	0	x $84.00	**$0.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$926.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$0.00**	
SUBTOTAL =				**$926.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$926.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐				**$0.00**	
TOTAL FEES ENCLOSED =				**$926.00**	
				Amount to be: refunded	$
				charged	$

a. ☒ PTO-2038 in the amount of **$926.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **11-0665** A duplicate copy of this sheet is enclosed.

d. ☒ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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M. Robert Kestenbaum
NAME

20,430
REGISTRATION NUMBER

December 18, 2001
DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: New US Patent Application corresponding to International Application PCT/DE00/02017
Filed June 27, 2000
Title CIRCUIT FOR SWITCHING ON AND OPERATING UNITS CONNECTED IN SERIES WITH REGARD TO THEIR POWER SUPPLY VOLTAGE IN A CONTROL AND DATA TRANSMISSION SYSTEM
Applicant Grewe et al
Attorney Docket (H) 01PH0405USP

Box PCT
Commissioner for Patents
Washington, DC 20231

Preliminary Amendment

Dear Sir or Madam:

Please amend the above-identified application as follows:

In the Specification:

A Substitute Specification and Abstract of the Disclosure are enclosed together with a Version with Markings to show Changes Made in this amendment.

In the Claims:

Please cancel claims 1 - 20 and insert the attached new claims 21 - 42.

Remarks

This Preliminary Amendment places the application text into US Style and Practice and removes multiple dependencies from the claims. Please calculate the Filing Fee according to this Preliminary Amendment.

Respectfully submitted,

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Claims:

21. An apparatus (1, 1', 1'') for modules (2, 2', 2'') connected to a supply voltage in series in a control and data transmission installation, comprising:

at least one supply voltage input (E, E', E'') and an associated supply voltage output (A, A', A''),

a connecting device (3, 3', 3'') for connecting the supply voltage input to the supply voltage output in response to

an ascertaining device (4, 4', 4'') for ascertaining at least one electrical variable at the supply voltage output.

22. The apparatus as claimed in claim 21, wherein the apparatus is arranged for use with a bus in an automation bus system.

23. The apparatus (1, 1', 1'') as claimed in claim 21, wherein the ascertaining device (4, 4', 4'') is arranged to ascertain at least one electrical variable for detecting at least one of an electrical load and a short circuit.

24. The apparatus as claimed in claim 21, wherein the apparatus (1, 1', 1'') is arranged to detect a flowing supply current.

25. The apparatus as claimed in claim 21, wherein the connecting device (3, 3', 3'') comprises at least one of a relay, a contactor and a semiconductor switch.

26. The apparatus as claimed in claim 22, wherein the apparatus (1, 1', 1') comprises a bus connection device for connection to an automation bus system.

27. The apparatus as claimed in claim 22, wherein the apparatus (1, 1', 1'') is of a design to be configurable at least one of manually and via the automation bus system, and has at least one memory device for configuration storage.

28. The apparatus as claimed in claim 21, wherein the apparatus has separate and electrically independent supply voltage inputs and outputs in each case for logic and for actuator equipment/sensor equipment of an associated module.

29. The apparatus as claimed in claim 21, wherein the apparatus (1, 1', 1'') comprises an associated module (2, 2', 2'') in a control and data transmission installation for a bus user in an automation bus system.

30. The apparatus as claimed in claim 29, wherein the associated module (2, 2', 2'') is connected to the supply voltage essentially downstream of the connecting device (3, 3', 3'').

31. The apparatus as claimed in claim 21, wherein the apparatus is arranged to detect a ground fault.

32. A control and data transmission installation, comprising at least one apparatus (1, 1', 1'') as claimed in claim 21, comprising at least one associated module (2, 2', 2'') that is electrically connected to the supply voltage in series with at least one other module, the apparatus being connected upstream of the other module.

33. A control and data transmission installation as claimed in claim 32, comprising a serial automation bus.

34. The control and data transmission installation as claimed in claim 33, wherein the automation bus comprises a bus in accordance with EN 50254, and at least a first module (2) of the modules (2, 2', 2'') connected to the supply voltage in series comprises an associated apparatus in a local bus section or bus spur.

35. A method for connecting and operating an apparatus as claimed in claim 21, comprising the following steps:

a) applying a supply voltage to the supply voltage input of the apparatus (1, 1', 1''),

b) detecting an electrical load or a short circuit at the supply voltage output (A, A', A''),

c) controlling the connecting device (3, 3',3'') for connecting the supply voltage input (E, E', E'') to the associated supply voltage output (A, A', A'') in response to a detected electrical load or short circuit.

36. The method as claimed in claim 35, wherein the controlling step c) comprises the following steps:

c1) comparing the detected load with a predetermined value, and

c2) connecting the supply voltage input (E, E', E'') to the associated supply voltage output (A, A', A'') if the detected load does not exceed the predetermined value.

37. The method as claimed in claim 35, wherein the controlling method step c) comprises the following step:

connecting the supply voltage input (E, E', E'') to the associated supply voltage output (A, A', A'') if no short circuit has been detected.

38. The method for connecting and operating an apparatus as claimed in claim 35, comprising the following additional steps:

detecting a flowing supply current, and

breaking the connection between the supply voltage input (E, E', E'') and the associated supply voltage output (A, A'; A'') if the detected supply current exceeds a predetermined value.

39. A method for connecting and operating series-connected apparatuses in a control and data transmission installation, comprising starting with a first apparatus (1), successfully connecting the apparatuses (1', 1', 1'') in each case as claimed in claim 34.

40. The method as claimed in claim 39, wherein the connection takes place automatically or is controlled via the automation bus.

41. The method as claimed in claim 39, wherein an apparatus (1, 1', 1'') connected only partially outputs an error message to indicate a short circuit or an overload at its voltage supply output, the error message being output to an indicator device or via the automation bus in order to control the automation bus system.

42. The method as claimed in claim 41, wherein the error message output via the automation bus comprises at least one data item for identifying the apparatus (1, 1', 1'') connected only partially.

"Version with Markings to show Changes Made"

Circuit for turning on and operating units connected to their supply voltage in series in a control and data transmission installation

Cross-References to Related Applications

Not applicable.

Statement Regarding Federally Sponsored Research or Development

Not applicable.

Background of the Invention

[0001] The invention relates to an apparatus for modules connected to the supply voltage in series in a control and data transmission installation, in particular for bus users in an automation bus system.

Technical Field

[0002] Modules in a control and data transmission installation, i.e. electrical components and units used in the design of an automation bus system, for example, are frequently connected to the supply voltage in series with one another. For this purpose, the units generally have a supply voltage input and a supply voltage output associated with the latter, this supply voltage output being connected to the supply voltage input of the next unit. If an individual unit in a number of units connected in series in this manner contains a short circuit, the supply voltage collapses generally for all the units, or the entire chain of units or modules cannot be started up, because the power supply unit reduces its output voltage on account of the short circuit, which means that the operation of individual units becomes an uncertainty. In addition, fault diagnosis is not possible, since none of the units are operational. The faulty unit can be ascertained only by removing all the units

from the series circuit and starting them up individually.

[0003] However, such a practice is extremely labor-intensive and time-consuming for the operation of today's very complex automation bus systems.

Summary of the Invention

[0004] It is thus an object of the invention to provide an apparatus which can be used to turn on modules connected to their supply voltage in series in a control and data transmission installation reliably during operation without there being the risk that the entire installation or at least relatively large sections will fail completely.

[0005] This object is achieved by [an apparatus having the features of claim 1, a control and data transmission installation having the features of claim 11, and with a method for connecting and operating such an apparatus as claimed in claim 13] an apparatus for modules connected to a supply voltage in series in a control and data transmission installation, comprising: at least one supply voltage input and an associated supply voltage output, a connecting device for connecting the supply voltage input to the supply voltage output in response to an ascertaining device for ascertaining at least one electrical variable at the supply voltage output. This object is also achieved by a control and data transmission installation, comprising at least one apparatus, comprising at least one associated module that is electrically connected to the supply voltage in series with at least one other module, the apparatus being connected upstream of the other module. This objective is also achieved by a method for connecting and operating the apparatus, comprising the following steps: a) applying a supply voltage to the supply voltage input of the apparatus, b) detecting an electrical load or a short circuit at the supply voltage output, c) controlling the connecting device for connecting the supply voltage input to the

associated supply voltage output in response to a detected electrical load or short circuit.

[0006] Accordingly, the inventive apparatus has at least one supply voltage input and at least one supply voltage output associated with the latter, and contains at least one first device for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken and a second device for detecting an electrical load and/or for detecting the supply current. In response to the detection of the electrical load and/or of the supply current, the supply voltage output can be connected to the supply voltage input. If, by way of example, a short circuit is detected at the supply voltage output, then the latter is not connected to the supply voltage input, which allows overloading of the device providing the supply voltage to be reliably prevented. If, on the other hand, no overload or short circuit is detected, then the supply voltage output is connected to the supply voltage input, and hence the module connected to the supply voltage output is connected to the supply voltage.

[0007] This also makes it possible to ensure that only the module or connecting line which has produced the short circuit or the overload is isolated from the supply voltage, and also the modules connected downstream of the fault location. For this purpose, each of the modules connected to the supply voltage in series can have an inventive apparatus. This apparatus is connected to the supply voltage upstream or downstream of the respective module. This allows all modules which are in use and are connected to the supply voltage in series to be fitted with the inventive apparatus retrospectively. However, it is also possible for the inventive apparatus to be integrated directly in the module, for example in a bus user, which makes it possible for the inventive apparatus to be of compact design with a module in a control and data transmission installation.

[0008] In addition, the fault location in a module connected in series can easily be detected using the inventive apparatus, since the modules upstream of the fault location can still be kept in operation without the supply voltage collapsing.

[0009] Depending on requirements, the device used for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken may be a relay, a contactor, and/or a semiconductor switch. In this context, in its normal position, the switch used isolates the supply voltage input from the associated supply voltage output. In this case, a semiconductor switch has the advantage that it is maintenance free and can easily be controlled electrically or electronically.

[0010] If the inventive apparatus is set up for connection to the automation bus, the apparatus can also be controlled directly by the control system of the automation bus system. By way of example, this allows the control system to disconnect or connect a particular module directly using the supply voltage. In addition, data traffic between the control system and the inventive apparatus is also made possible.

[0011] To match the inventive apparatus to the respective requirements of the associated module, a memory device for storing the configuration of the devices of the apparatus may be included. By way of example, the configuration comprises a prescribed limit value for the supply current and/or for the electrical load, at which current or load the first device isolates the supply voltage output from the supply voltage input. This configuration may advantageously be carried out manually on the apparatus itself and/or via the automation bus. As already explained above, the apparatus can be integrated directly into the associated module, that is to say the module to be protected. This has the particular advantage that any bus interface which already exists on the module, for

example the interface on a bus user in the automation bus system, can also be used for the inventive apparatus for connection to the bus.

[0012] Advantageously, the inventive apparatus may have separate supply voltage inputs and outputs in each case for the logic and for the actuator equipment/sensor equipment of the associated module, which makes it possible to separate the supply voltage for the logic circuits and for the actuator equipment/sensor equipment circuits of the associated module. Since the respective supply voltage outputs are operated by independent switches, failure of the actuator equipment/sensor equipment, for example, the relevant module can be kept in operation at least to a limited extent, for example for diagnostic purposes, using the logic circuits.

[0013] The inventive apparatus can be used in a wide variety of ways when designing an automation bus system, in particular when designing a serial automation bus system. To simplify the illustration, it is initially assumed that the inventive apparatus comprises its associated module itself. This is equivalent to the inventive apparatus being regarded as integrated in the module.

[0014] As has been explained above and becomes clear below in the description of a few exemplary embodiments, the invention is not limited to this, however, since, in principle, any module connected to the supply voltage in series in a control and data transmission installation can have an inventive apparatus connected upstream or downstream of it. This allows any control and data transmission installation to be fitted with inventive apparatuses retrospectively by connecting an inventive apparatus to the supply voltage upstream or downstream of the respective module.

[0015] In the simplest case, a module comprising an inventive apparatus is electrically

connected to its supply voltage in series with another module, the other module being connected downstream of the first-mentioned module. In the event of a fault, for example an overload or a short circuit in the module connected downstream, the supply voltage output of the first module, and hence also the supply voltage input of the module connected downstream, is isolated from the supply voltage by the inventive apparatus, so that the first module can remain in operation. In principle, any number of modules connected in series in an automation bus system can be protected from the supply voltage in this manner. Optimum protection by the inventive apparatus is provided if all the series-connected modules apart from the last one have an inventive apparatus. If, however, the inventive apparatus is connected in the module essentially upstream of the actual circuits, i.e. loads associated with the module, in which an overload or a short circuit can arise by way of preference, this last module should also be designed to be in series with the inventive apparatus, since a fault caused by the loads associated with the module is detected using the associated inventive apparatus and is eliminated by isolation from the supply voltage, so that the modules connected upstream can all continue to operate.

[0016] If an overload occurs or a prescribed supply limit current is exceeded during operation, the inventive apparatus can isolate the supply voltage output from the associated supply voltage input, so that the modules or units connected upstream of this module can continue to operate. In this case, the device for detecting the supply current which is flowing may also be set up to detect a ground fault, for example using differential current formation.

[0017] In another embodiment of the invention, it is also possible for the supply voltage

[0017] In another embodiment of the invention, it is also possible for the supply voltage output to be connected to the supply voltage input with current limiting in the event of a fault, which means that, firstly, the subsequent modules can sometimes continue to operate at least to some extent, and, secondly, there is a risk that the modules connected upstream will fail on account of the supply voltage device for the series-connected units being overloaded, because the supply voltage collapses. Such a fault situation covers the occurrence of an electrical overload but not of a "hard" short circuit, in which case the supply voltage would collapse despite current limiting.

[0018] The inventive apparatus also makes it possible to start up the series-connected units or modules reliably. Depending on the embodiment of the invention, this can be done either automatically by the modules themselves using successive connection or via the bus under the control of the controller. The last connected module, whose inventive apparatus no longer connects the supply voltage input to the supply voltage output, or now connects them only with current limiting, is advantageously designed to output an error message. In this case, the fault is indicated on the relevant module or the inventive apparatus, or an error message is sent to the controller via the bus. To provide for rapid identification of the fault location, the error message can comprise a data item for identifying the relevant module.

Brief Description of the Drawings

[0019] The invention is explained below by describing a few embodiments on the basis of the appended drawings, in which:

[0020] Fig.1 shows a schematic block diagram of modules electrically connected in series in an automation bus system, with associated inventive apparatuses in the quiescent

[0021] Fig.2 shows the apparatuses from figure 1 in the connecting phase,

[0022] Fig.3 shows a schematic block diagram of inventive apparatuses connected in electrical series, with integrated bus users, and

[0023] Fig.4 shows another schematic block diagram of a series circuit comprising inventive apparatuses with integrated bus users, the first apparatus having an additional device for detecting the supply current which is flowing.

Detailed Description of the Invention

[0024] Figure 1 shows a first embodiment of the inventive apparatus and the arrangement thereof in a control and data transmission installation, which is an automation bus system in the present case. Figure 1 shows a detail of the automation bus system, in which a plurality of bus users 2, 2', 2'' are connected to their supply voltage in series. Connected between these modules is a respective inventive apparatus 1, 1', 1''. Each bus user thus has an associated inventive apparatus. However, it is also possible for one inventive apparatus to be associated with a plurality of bus users connected to the supply voltage in series. In this case, an inventive apparatus is connected to the supply voltage at the start of the series circuit, and the bus users connected subsequently in series are connected downstream of said apparatus.

[0025] Each of the inventive apparatuses comprises at least one supply voltage input E, E', E'' and an associated supply voltage output A, A', A''. Connected between the respective supply voltage input and output is a device 3, 3' 3'' which is able to connect the respective input to the associated output. In this context, the connecting device is controlled by a device 4, 4', 4'' for ascertaining at least one electrical variable at the supply voltage output.

[0026] According to the invention, the term supply voltage output denotes points on the supply voltage path which are disposed downstream of the connecting switch of the inventive apparatus. Accordingly, the term supply voltage input denotes points on the supply voltage path which are disposed upstream of the connecting switch of the inventive apparatus. Any connection devices for the supply voltage, for example for connecting the inventive apparatuses to routing conductors, are naturally also included in this definition.

[0027] One connecting devices (3, 3', 3'') is off if no supply voltage is applied to the supply voltage input of the inventive apparatus. If no supply voltage is applied to the first inventive apparatus 1, this is also the case on all the subsequent apparatuses 1' and 1'', and all the connecting devices 3, 3' and 3'' are off. In the embodiment shown, the connecting device 3, 3', 3'' is a semiconductor switch which is controlled by the device 4, 4', 4''. In the present case, this device 4, 4' or 4'' for ascertaining an electrical variable is a device which is designed to detect an electrical load at the supply voltage output. If the ascertained load exceeds a predetermined value, the respective connecting device 3, 3', 3'' remains off. In this case, the electrical loads associated with the inventive apparatus 1, 1' or 1'' are connected at the supply voltage input E, E' or E''. To ascertain the electrical load at the supply voltage output, a low voltage is applied with current limiting to the supply voltage output, said voltage being so low that the subsequent module, i.e. the subsequent bus user, is not started up. The devices 4, 4', 4'' each have a current measuring apparatus which can be used to detect the current which is flowing, via the supply voltage output. If the ascertained flow of current exceeds a predetermined value, or even if the current limiting section responds, the supply voltage applied to the

respective supply voltage input cannot be connected through to the associated supply voltage output, and the connecting device 3, 3', 3'', i.e. the respective semiconductor switch, remains off. This is a way of, firstly, reliably detecting an overload in the downstream supply voltage line or in one of the subsequent bus users, and also, by virtue of the semiconductor switch not turning on, of preventing the voltage supply from collapsing for all the series-connected bus users.

[0028] The way in which the inventive apparatus works is shown particularly when turning on the voltage supply for the bus section shown in figure 1. Figure 2 shows the final state for the case in which, when turning on, an illustrative overload exists and has been detected in third load 2'' upstream of the third inventive apparatus 1''. When turning on the voltage supply for the bus users 2, 2' and 2'' connected to the supply voltage in series, the supply voltage is first applied to the first bus user 2. The supply voltage is looped through this bus user 2 and is thus also applied to the inventive apparatus 1. The connecting device 3 of said apparatus is initially off, which means that there is no supply voltage at the supply voltage output A thereof, and accordingly the subsequent bus user 2' is not connected. As soon as the supply voltage is applied to the supply voltage input of the apparatus 1, a turn-on procedure stored in the apparatus is automatically performed. Within the scope of this, the electrical load present at the supply voltage output is first ascertained. This is done by applying a low voltage with current limiting to the supply voltage output A of the apparatus 1 and ascertaining the resultant flow of current using the device 4. In the embodiment described, the low voltage is just a few volts, e.g. approximately 3 volts, is thus far below the 24 volts required by the bus users, which means that the subsequent bus user 2' is not connected by applying the low

voltage.

[0029] This measure is used to check the supply voltage line from the apparatus 1 to the bus user 2', and the supply voltage line from this bus user to the apparatus 1', and the bus user 2' itself. An existing electrical overload on account of a fault or even a short circuit within the areas cited is thus detected. In the present case, there is no electrical overload, which means that the device 3 for connecting the supply voltage input E to the associated supply voltage A is controlled such that the device 3 connects the output and the input to one another, with the result that the supply voltage is now fully present at the supply voltage output A and hence also on the second bus user 2', which means that the latter is also connected. As in the first bus user, the supply voltage is again looped through the bus user and is thus applied to the supply voltage input E' of the second inventive apparatus 1'. The turn-on procedure described is now performed in the second apparatus 2' too. In this case, however, an overload is detected in the third load 2''. In contrast to the sequence in the first inventive apparatus 1, the device 3' in the apparatus 1' is not controlled to connect the supply voltage input to the associated supply voltage output, which means that the device 3' remains off. In this way, the inventive apparatus 1' prevents the overload from causing all the bus users among the bus users connected to the supply voltage in series to fail on account of the voltage supply unit being overloaded. Instead, only all the bus users which are situated upstream of the fault location in the series arrangement are connected. The apparatus 1' connected last, only partially, indicates the connection fault which has arisen using an indicator device (not shown in figure 2). According to the invention, an apparatus is connected only partially when, although the apparatus is being supplied with electricity and is in operation, the

connecting device, in this case 3', is off. The manner described, i.e. using a fault indicator on the inventive apparatus which is not connected fully, makes it a simple matter to conduct a fault search even when there are a large number of modules, for example bus users, connected to the supply voltage in series.

[0030] To be able to match the inventive apparatus flexibly to the respective requirements, in particular to the supply currents based on the respective bus users, the apparatuses 1, 1' and 1'' each comprise a device for configuring the apparatus. The maximum electrical load permitted at the supply voltage output can be set manually, for example on the respective apparatuses, and this is used to stipulate the response of the connecting device 3, 3', 3''.

[0031] During operation, in the embodiment described, the device 4, 4' or 4'' is used to detect the supply current which is flowing, and if a predetermined value is exceeded, the device 3, 3' or 3'' is controlled to break the connection between the particular supply voltage input and the associated supply voltage output.

[0032] Another embodiment of the invention and its use in an automation bus system is shown in the schematic block diagram in figure 3. Again, as part of a control and data transmission installation, three inventive apparatuses 1, 1' and 1'', and also the associated bus users 2, 2' and 2'', are connected to the supply voltage in series. In this context, the bus user is integrated in the inventive apparatus in each case. In the embodiment shown, the respective bus users, i.e. the electrical loads associated with the bus user, are electrically connected downstream of the respective device for detecting a short circuit 4, 4', 4'', so that the inventive apparatus also checks the associated bus user for a short circuit. In the embodiment of the invention shown in figure 3, the device 4, 4' or 4'' is

respectively designed to detect a short circuit. For this, it impresses a predetermined current into the respective supply voltage output when the connecting device 3, 3' or 3'' is off. A short circuit downstream of the supply voltage output results in a voltage drop at the supply voltage output, which is detected. In response to the ascertained short circuit in the downstream supply voltage line or the subsequent bus users, the connecting device remains off, so that there is ultimately no voltage at the supply voltage output of the respective apparatus. This is thus also true for the bus user contained in the inventive apparatus, which means that this bus user is not connected either. In another embodiment of the invention, however, not all of the devices or loads associated with the bus user are connected downstream of the respective connecting device 3, 3' or 3'', but rather at least some of them are connected upstream of it. Accordingly, if a supply voltage is applied to the supply voltage input, the bus user is connected at least partially. This applies in particular to a special embodiment of the invention in which the bus user's bus connection is connected to its supply voltage upstream of the connecting device, which means that the bus connection is capable of operating when a voltage is applied to the supply voltage input. This bus connection of the bus user is also used for configuring the connecting device 3, 3' or 3''. For this, in the special embodiment, the inventive apparatus has a memory device for storing the configuration which has been set via the bus.

[0033] The method already described above for connecting the apparatuses or the bus users is also used in the case shown in figure 3 to detect a short circuit on the supply voltage connection between the second and third inventive apparatuses, and hence the connecting devices 3' and 3'' are not turned on, which means that the associated bus users 2' and 2''

are not connected. The first inventive apparatus 1, including the associated bus user 2, are both connected as prescribed, however.

[0034] In figure 4, the inventive apparatus 1 denotes another development of the inventive apparatus. The devices for ascertaining an electrical variable 4, 4', 4'' correspond to those in figure 3, i.e. a fault in the downstream supply voltage line or in the subsequent bus user is detected by impressing a current on the respective supply voltage output. In addition, the respective associated bus users 2 are integrated in the apparatuses, with the bus connection not being shown, as in figure 3. In contrast to the inventive apparatuses in figure 3, the first apparatus 1 also comprises an apparatus for detecting the supply current which is flowing. In this context, during fault-free operation, this supply current which is flowing comprises at least the supply current for the modules connected in series and the supply current for the associated inventive apparatuses. In the embodiment described, the device 5 is connected directly downstream of the supply voltage input E of the apparatus 1, but may also be connected at the supply voltage output A of the apparatus, for example. The device measures the supply current flowing during operation of the series circuit (shown only in part) comprising inventive apparatuses with the associated bus users. Since the additional device is connected at the beginning of the series circuit, an electrical overload or a short circuit is thus reliably detected after all the series-connected apparatuses with associated modules have been connected. In this way, an increased current requirement for the series circuit during operation of the control and data transmission installation is reliably ascertained, and the necessary measures are taken.

[0035] The current detection device 5 is designed to control the connecting device 3. If an electrical overload or a short circuit arises during operation, the inventive apparatus 1 can

thus interrupt the voltage supply for all the series-connected apparatuses with associated bus users by isolating the supply voltage input E from the supply voltage A as a result of an appropriate response from the device 3. The snapshot illustration shown in figure 4 identifies this situation.

[0036] Since isolation of the supply voltage input E from the supply voltage output A means that all the other inventive apparatuses 1' and 1'' are nonlive, the devices 3' and 3'' in them then turn off. The connecting device 3 is in the form of a fast semiconductor switch, and hence the supply voltage continues to be applied to the supply voltage input A of the device 1, because the power supply unit for the supply voltage continues to be capable of operation.

[0037] As described above, the connection procedure now starts in the apparatus 1 as a result. Since no short circuit can now be detected at the supply voltage output A, the device 3 connects the supply voltage to the supply voltage output A. This supply voltage is then applied to the supply voltage input E' of the apparatus 1', which means that the turn-on procedure starts in the apparatus 1'. As a result of the device 4' impressing the current into the supply voltage output A', the short circuit in the apparatus 1'' is detected, which means that the connecting device 3' remains off. The turn-on operation has thus ended. In summary, this detects a short circuit arising during operation and initially disconnects the bus users connected to the supply voltage in series and then automatically connects them again one after the other, i.e. successively; up to the fault location.

[0038] This successive connection of the individual bus users by means of the inventive apparatuses is naturally also performed during normal "startup" of the control and data transmission installation.

[0039] In one embodiment (not shown) of the invention, the inventive apparatus has separate and electrically independent supply voltage inputs and outputs in each case for the logic and for the actuator equipment/sensor equipment of the associated module. Accordingly, a bus user does not fail completely when, by way of example, the voltage supply for the actuator equipment/sensor equipment has failed, because the logic of the bus user continues to be capable of operation.

[0040] In another embodiment of the invention, the apparatus can additionally be connected to the automation bus and controlled by the system controller via an interface. By way of example, the controller can be used to control the connecting device when required, in order to connect the supply voltage input to the associated supply voltage output, or to isolate them. The inventive apparatus which has been connected only partially, i.e. its connecting device has not been controlled to connect the supply voltage input to the associated supply voltage output, outputs an error message to the controller via the automation bus. In this case, this error message comprises a data item which can be used to identify the apparatus concerned.

[0041] The inventive apparatus can, in principle, be used in all control and data transmission installations, that is to say, for example, in automation bus systems and, particularly, also in systems having a serial automation bus, such as a bus in accordance with EN 50254. According to requirements, each of the modules of the automation bus system which are connected to the supply voltage in series may in this case be assigned an inventive apparatus in the manner described. This applies not only to the entire system but also, in particular, to modules in an individual local bus section or a bus spur in the automation bus system. However, it is also possible for just one inventive apparatus to be assigned to

a plurality of modules connected in succession in the automation bus system, so that the relevant modules connected to the supply voltage in series are all turned on and off together by the individual inventive apparatus.

[0042] In one embodiment (not shown), the inventive apparatus is set up to detect a ground fault. In this case, the differential current between plus and minus on the supply line is detected, and, in response to this differential current, the supply voltage input is isolated from the supply voltage output if a prescribed value is exceeded, so that the supply current for the components connected downstream of the supply voltage output is interrupted.

Abstract of the Disclosure

[The invention relates to an apparatus for modules connected to the supply voltage in series in a control and data transmission installation for turning on and operating the modules.]

To provide an apparatus which can be used to turn on the series-connected modules in a control and data transmission installation reliably during operation without a short circuit presenting the risk that the entire installation or at least relatively large sections fail completely or cannot be started up, an apparatus is provided which has a supply voltage input and a supply voltage output associated with the latter, and contains a first device for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken and a second device for detecting an electrical load and/or for detecting the supply current. The inventive apparatus is connected to the supply voltage upstream or downstream of the associated module. Before the supply voltage input is connected to the associated supply voltage output, the supply voltage output is checked for an overload or a short circuit. If, by way of example, a short circuit is detected, then the supply voltage output is not connected to the supply voltage input, which means that overloading of the device providing the supply voltage can be reliably prevented. A plurality of modules which are connected in series and have respectively associated inventive apparatuses are connected successively, so that the series of modules can be started up at least up to the fault location.

Circuit for turning on and operating units connected to their supply voltage in series in a control and data transmission installation

Cross-References to Related Applications

Not applicable.

Statement Regarding Federally Sponsored Research or Development

Not applicable.

Background of the Invention

[0001] The invention relates to an apparatus for modules connected to the supply voltage in series in a control and data transmission installation, in particular for bus users in an automation bus system.

Technical Field

[0002] Modules in a control and data transmission installation, i.e. electrical components and units used in the design of an automation bus system, for example, are frequently connected to the supply voltage in series with one another. For this purpose, the units generally have a supply voltage input and a supply voltage output associated with the latter, this supply voltage output being connected to the supply voltage input of the next unit. If an individual unit in a number of units connected in series in this manner contains a short circuit, the supply voltage collapses generally for all the units, or the entire chain of units or modules cannot be started up, because the power supply unit reduces its output voltage on account of the short circuit, which means that the operation of individual units becomes an uncertainty. In addition, fault diagnosis is not possible, since none of the units are operational. The faulty unit can be ascertained only by removing all the units from the series circuit and starting them up individually.

[0003] However, such a practice is extremely labor-intensive and time-consuming for the operation of today's very complex automation bus systems.

Summary of the Invention

[0004] It is thus an object of the invention to provide an apparatus which can be used to turn on modules connected to their supply voltage in series in a control and data transmission installation reliably during operation without there being the risk that the entire installation or at least relatively large sections will fail completely.

[0005] This object is achieved by an apparatus for modules connected to a supply voltage in series in a control and data transmission installation, comprising: at least one supply voltage input and an associated supply voltage output, a connecting device for connecting the supply voltage input to the supply voltage output in response to an ascertaining device for ascertaining at least one electrical variable at the supply voltage output. This object is also achieved by a control and data transmission installation, comprising at least one apparatus, comprising at least one associated module that is electrically connected to the supply voltage in series with at least one other module, the apparatus being connected upstream of the other module. This objective is also achieved by a method for connecting and operating the apparatus, comprising the following steps: a) applying a supply voltage to the supply voltage input of the apparatus, b) detecting an electrical load or a short circuit at the supply voltage output, c) controlling the connecting device for connecting the supply voltage input to the associated supply voltage output in response to a detected electrical load or short circuit.

[0006] Accordingly, the inventive apparatus has at least one supply voltage input and at least one supply voltage output associated with the latter, and contains at least one first device

for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken and a second device for detecting an electrical load and/or for detecting the supply current. In response to the detection of the electrical load and/or of the supply current, the supply voltage output can be connected to the supply voltage input. If, by way of example, a short circuit is detected at the supply voltage output, then the latter is not connected to the supply voltage input, which allows overloading of the device providing the supply voltage to be reliably prevented. If, on the other hand, no overload or short circuit is detected, then the supply voltage output is connected to the supply voltage input, and hence the module connected to the supply voltage output is connected to the supply voltage.

[0007] This also makes it possible to ensure that only the module or connecting line which has produced the short circuit or the overload is isolated from the supply voltage, and also the modules connected downstream of the fault location. For this purpose, each of the modules connected to the supply voltage in series can have an inventive apparatus. This apparatus is connected to the supply voltage upstream or downstream of the respective module. This allows all modules which are in use and are connected to the supply voltage in series to be fitted with the inventive apparatus retrospectively. However, it is also possible for the inventive apparatus to be integrated directly in the module, for example in a bus user, which makes it possible for the inventive apparatus to be of compact design with a module in a control and data transmission installation.

[0008] In addition, the fault location in a module connected in series can easily be detected using the inventive apparatus, since the modules upstream of the fault location can still be kept in operation without the supply voltage collapsing.

[0009] Depending on requirements, the device used for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken may be a relay, a contactor, and/or a semiconductor switch. In this context, in its normal position, the switch used isolates the supply voltage input from the associated supply voltage output. In this case, a semiconductor switch has the advantage that it is maintenance free and can easily be controlled electrically or electronically.

[0010] If the inventive apparatus is set up for connection to the automation bus, the apparatus can also be controlled directly by the control system of the automation bus system. By way of example, this allows the control system to disconnect or connect a particular module directly using the supply voltage. In addition, data traffic between the control system and the inventive apparatus is also made possible.

[0011] To match the inventive apparatus to the respective requirements of the associated module, a memory device for storing the configuration of the devices of the apparatus may be included. By way of example, the configuration comprises a prescribed limit value for the supply current and/or for the electrical load, at which current or load the first device isolates the supply voltage output from the supply voltage input. This configuration may advantageously be carried out manually on the apparatus itself and/or via the automation bus. As already explained above, the apparatus can be integrated directly into the associated module, that is to say the module to be protected. This has the particular advantage that any bus interface which already exists on the module, for example the interface on a bus user in the automation bus system, can also be used for the inventive apparatus for connection to the bus.

[0012] Advantageously, the inventive apparatus may have separate supply voltage inputs and

outputs in each case for the logic and for the actuator equipment/sensor equipment of the associated module, which makes it possible to separate the supply voltage for the logic circuits and for the actuator equipment/sensor equipment circuits of the associated module. Since the respective supply voltage outputs are operated by independent switches, failure of the actuator equipment/sensor equipment, for example, the relevant module can be kept in operation at least to a limited extent, for example for diagnostic purposes, using the logic circuits.

[0013] The inventive apparatus can be used in a wide variety of ways when designing an automation bus system, in particular when designing a serial automation bus system. To simplify the illustration, it is initially assumed that the inventive apparatus comprises its associated module itself. This is equivalent to the inventive apparatus being regarded as integrated in the module.

[0014] As has been explained above and becomes clear below in the description of a few exemplary embodiments, the invention is not limited to this, however, since, in principle, any module connected to the supply voltage in series in a control and data transmission installation can have an inventive apparatus connected upstream or downstream of it. This allows any control and data transmission installation to be fitted with inventive apparatuses retrospectively by connecting an inventive apparatus to the supply voltage upstream or downstream of the respective module.

[0015] In the simplest case, a module comprising an inventive apparatus is electrically connected to its supply voltage in series with another module, the other module being connected downstream of the first-mentioned module. In the event of a fault, for example an overload or a short circuit in the module connected downstream, the supply voltage

output of the first module, and hence also the supply voltage input of the module connected downstream, is isolated from the supply voltage by the inventive apparatus, so that the first module can remain in operation. In principle, any number of modules connected in series in an automation bus system can be protected from the supply voltage in this manner. Optimum protection by the inventive apparatus is provided if all the series-connected modules apart from the last one have an inventive apparatus. If, however, the inventive apparatus is connected in the module essentially upstream of the actual circuits, i.e. loads associated with the module, in which an overload or a short circuit can arise by way of preference, this last module should also be designed to be in series with the inventive apparatus, since a fault caused by the loads associated with the module is detected using the associated inventive apparatus and is eliminated by isolation from the supply voltage, so that the modules connected upstream can all continue to operate.

[0016] If an overload occurs or a prescribed supply limit current is exceeded during operation, the inventive apparatus can isolate the supply voltage output from the associated supply voltage input, so that the modules or units connected upstream of this module can continue to operate. In this case, the device for detecting the supply current which is flowing may also be set up to detect a ground fault, for example using differential current formation.

[0017] In another embodiment of the invention, it is also possible for the supply voltage output to be connected to the supply voltage input with current limiting in the event of a fault, which means that, firstly, the subsequent modules can sometimes continue to operate at least to some extent, and, secondly, there is a risk that the modules connected

upstream will fail on account of the supply voltage device for the series-connected units being overloaded, because the supply voltage collapses. Such a fault situation covers the occurrence of an electrical overload but not of a "hard" short circuit, in which case the supply voltage would collapse despite current limiting.

[0018] The inventive apparatus also makes it possible to start up the series-connected units or modules reliably. Depending on the embodiment of the invention, this can be done either automatically by the modules themselves using successive connection or via the bus under the control of the controller. The last connected module, whose inventive apparatus no longer connects the supply voltage input to the supply voltage output, or now connects them only with current limiting, is advantageously designed to output an error message. In this case, the fault is indicated on the relevant module or the inventive apparatus, or an error message is sent to the controller via the bus. To provide for rapid identification of the fault location, the error message can comprise a data item for identifying the relevant module.

Brief Description of the Drawings

[0019] The invention is explained below by describing a few embodiments on the basis of the appended drawings, in which:

[0020] Fig.1 shows a schematic block diagram of modules electrically connected in series in an automation bus system, with associated inventive apparatuses in the quiescent state,

[0021] Fig.2 shows the apparatuses from figure 1 in the connecting phase,

[0022] Fig.3 shows a schematic block diagram of inventive apparatuses connected in electrical series, with integrated bus users, and

[0023] Fig.4 shows another schematic block diagram of a series circuit comprising inventive apparatuses with integrated bus users, the first apparatus having an additional device for detecting the supply current which is flowing.

Detailed Description of the Invention

[0024] Figure 1 shows a first embodiment of the inventive apparatus and the arrangement thereof in a control and data transmission installation, which is an automation bus system in the present case. Figure 1 shows a detail of the automation bus system, in which a plurality of bus users 2, 2', 2'' are connected to their supply voltage in series. Connected between these modules is a respective inventive apparatus 1, 1', 1''. Each bus user thus has an associated inventive apparatus. However, it is also possible for one inventive apparatus to be associated with a plurality of bus users connected to the supply voltage in series. In this case, an inventive apparatus is connected to the supply voltage at the start of the series circuit, and the bus users connected subsequently in series are connected downstream of said apparatus.

[0025] Each of the inventive apparatuses comprises at least one supply voltage input E, E', E'' and an associated supply voltage output A, A', A''. Connected between the respective supply voltage input and output is a device 3, 3' 3'' which is able to connect the respective input to the associated output. In this context, the connecting device is controlled by a device 4, 4', 4'' for ascertaining at least one electrical variable at the supply voltage output.

[0026] According to the invention, the term supply voltage output denotes points on the supply voltage path which are disposed downstream of the connecting switch of the inventive apparatus. Accordingly, the term supply voltage input denotes points on the

supply voltage path which are disposed upstream of the connecting switch of the inventive apparatus. Any connection devices for the supply voltage, for example for connecting the inventive apparatuses to routing conductors, are naturally also included in this definition.

[0027] One connecting devices (3, 3', 3'') is off if no supply voltage is applied to the supply voltage input of the inventive apparatus. If no supply voltage is applied to the first inventive apparatus 1, this is also the case on all the subsequent apparatuses 1' and 1'', and all the connecting devices 3, 3' and 3'' are off. In the embodiment shown, the connecting device 3, 3', 3'' is a semiconductor switch which is controlled by the device 4, 4', 4''. In the present case, this device 4, 4' or 4'' for ascertaining an electrical variable is a device which is designed to detect an electrical load at the supply voltage output. If the ascertained load exceeds a predetermined value, the respective connecting device 3, 3', 3'' remains off. In this case, the electrical loads associated with the inventive apparatus 1, 1' or 1'' are connected at the supply voltage input E, E' or E''. To ascertain the electrical load at the supply voltage output, a low voltage is applied with current limiting to the supply voltage output, said voltage being so low that the subsequent module, i.e. the subsequent bus user, is not started up. The devices 4, 4', 4'' each have a current measuring apparatus which can be used to detect the current which is flowing, via the supply voltage output. If the ascertained flow of current exceeds a predetermined value, or even if the current limiting section responds, the supply voltage applied to the respective supply voltage input cannot be connected through to the associated supply voltage output, and the connecting device 3, 3', 3'', i.e. the respective semiconductor switch, remains off. This is a way of, firstly, reliably detecting an overload in the

downstream supply voltage line or in one of the subsequent bus users, and also, by virtue of the semiconductor switch not turning on, of preventing the voltage supply from collapsing for all the series-connected bus users.

[0028] The way in which the inventive apparatus works is shown particularly when turning on the voltage supply for the bus section shown in figure 1. Figure 2 shows the final state for the case in which, when turning on, an illustrative overload exists and has been detected in third load 2'' upstream of the third inventive apparatus 1''. When turning on the voltage supply for the bus users 2, 2' and 2'' connected to the supply voltage in series, the supply voltage is first applied to the first bus user 2. The supply voltage is looped through this bus user 2 and is thus also applied to the inventive apparatus 1. The connecting device 3 of said apparatus is initially off, which means that there is no supply voltage at the supply voltage output A thereof, and accordingly the subsequent bus user 2' is not connected. As soon as the supply voltage is applied to the supply voltage input of the apparatus 1, a turn-on procedure stored in the apparatus is automatically performed. Within the scope of this, the electrical load present at the supply voltage output is first ascertained. This is done by applying a low voltage with current limiting to the supply voltage output A of the apparatus 1 and ascertaining the resultant flow of current using the device 4. In the embodiment described, the low voltage is just a few volts, e.g. approximately 3 volts, is thus far below the 24 volts required by the bus users, which means that the subsequent bus user 2' is not connected by applying the low voltage.

[0029] This measure is used to check the supply voltage line from the apparatus 1 to the bus user 2', and the supply voltage line from this bus user to the apparatus 1', and the bus

user 2' itself. An existing electrical overload on account of a fault or even a short circuit within the areas cited is thus detected. In the present case, there is no electrical overload, which means that the device 3 for connecting the supply voltage input E to the associated supply voltage A is controlled such that the device 3 connects the output and the input to one another, with the result that the supply voltage is now fully present at the supply voltage output A and hence also on the second bus user 2', which means that the latter is also connected. As in the first bus user, the supply voltage is again looped through the bus user and is thus applied to the supply voltage input E' of the second inventive apparatus 1'. The turn-on procedure described is now performed in the second apparatus 2' too. In this case, however, an overload is detected in the third load 2''. In contrast to the sequence in the first inventive apparatus 1, the device 3' in the apparatus 1' is not controlled to connect the supply voltage input to the associated supply voltage output, which means that the device 3' remains off. In this way, the inventive apparatus 1' prevents the overload from causing all the bus users among the bus users connected to the supply voltage in series to fail on account of the voltage supply unit being overloaded. Instead, only all the bus users which are situated upstream of the fault location in the series arrangement are connected. The apparatus 1' connected last, only partially, indicates the connection fault which has arisen using an indicator device (not shown in figure 2). According to the invention, an apparatus is connected only partially when, although the apparatus is being supplied with electricity and is in operation, the connecting device, in this case 3', is off. The manner described, i.e. using a fault indicator on the inventive apparatus which is not connected fully, makes it a simple matter to conduct a fault search even when there are a large number of modules, for example bus

users, connected to the supply voltage in series.

[0030] To be able to match the inventive apparatus flexibly to the respective requirements, in particular to the supply currents based on the respective bus users, the apparatuses 1, 1' and 1'' each comprise a device for configuring the apparatus. The maximum electrical load permitted at the supply voltage output can be set manually, for example on the respective apparatuses, and this is used to stipulate the response of the connecting device 3, 3', 3''.

[0031] During operation, in the embodiment described, the device 4, 4' or 4'' is used to detect the supply current which is flowing, and if a predetermined value is exceeded, the device 3, 3' or 3'' is controlled to break the connection between the particular supply voltage input and the associated supply voltage output.

[0032] Another embodiment of the invention and its use in an automation bus system is shown in the schematic block diagram in figure 3. Again, as part of a control and data transmission installation, three inventive apparatuses 1, 1' and 1'', and also the associated bus users 2, 2' and 2'', are connected to the supply voltage in series. In this context, the bus user is integrated in the inventive apparatus in each case. In the embodiment shown, the respective bus users, i.e. the electrical loads associated with the bus user, are electrically connected downstream of the respective device for detecting a short circuit 4, 4', 4'', so that the inventive apparatus also checks the associated bus user for a short circuit. In the embodiment of the invention shown in figure 3, the device 4, 4' or 4'' is respectively designed to detect a short circuit. For this, it impresses a predetermined current into the respective supply voltage output when the connecting device 3, 3' or 3'' is off. A short circuit downstream of the supply voltage output results in a voltage drop at

the supply voltage output, which is detected. In response to the ascertained short circuit in the downstream supply voltage line or the subsequent bus users, the connecting device remains off, so that there is ultimately no voltage at the supply voltage output of the respective apparatus. This is thus also true for the bus user contained in the inventive apparatus, which means that this bus user is not connected either. In another embodiment of the invention, however, not all of the devices or loads associated with the bus user are connected downstream of the respective connecting device 3, 3' or 3'', but rather at least some of them are connected upstream of it. Accordingly, if a supply voltage is applied to the supply voltage input, the bus user is connected at least partially. This applies in particular to a special embodiment of the invention in which the bus user's bus connection is connected to its supply voltage upstream of the connecting device, which means that the bus connection is capable of operating when a voltage is applied to the supply voltage input. This bus connection of the bus user is also used for configuring the connecting device 3, 3' or 3''. For this, in the special embodiment, the inventive apparatus has a memory device for storing the configuration which has been set via the bus.

[0033] The method already described above for connecting the apparatuses or the bus users is also used in the case shown in figure 3 to detect a short circuit on the supply voltage connection between the second and third inventive apparatuses, and hence the connecting devices 3' and 3'' are not turned on, which means that the associated bus users 2' and 2'' are not connected. The first inventive apparatus 1, including the associated bus user 2, are both connected as prescribed, however.

[0034] In figure 4, the inventive apparatus 1 denotes another development of the inventive

apparatus. The devices for ascertaining an electrical variable 4, 4', 4'' correspond to those in figure 3, i.e. a fault in the downstream supply voltage line or in the subsequent bus user is detected by impressing a current on the respective supply voltage output. In addition, the respective associated bus users 2 are integrated in the apparatuses, with the bus connection not being shown, as in figure 3. In contrast to the inventive apparatuses in figure 3, the first apparatus 1 also comprises an apparatus for detecting the supply current which is flowing. In this context, during fault-free operation, this supply current which is flowing comprises at least the supply current for the modules connected in series and the supply current for the associated inventive apparatuses. In the embodiment described, the device 5 is connected directly downstream of the supply voltage input E of the apparatus 1, but may also be connected at the supply voltage output A of the apparatus, for example. The device measures the supply current flowing during operation of the series circuit (shown only in part) comprising inventive apparatuses with the associated bus users. Since the additional device is connected at the beginning of the series circuit, an electrical overload or a short circuit is thus reliably detected after all the series-connected apparatuses with associated modules have been connected. In this way, an increased current requirement for the series circuit during operation of the control and data transmission installation is reliably ascertained, and the necessary measures are taken.

[0035] The current detection device 5 is designed to control the connecting device 3. If an electrical overload or a short circuit arises during operation, the inventive apparatus 1 can thus interrupt the voltage supply for all the series-connected apparatuses with associated bus users by isolating the supply voltage input E from the supply voltage A as a result of an appropriate response from the device 3. The snapshot illustration shown in figure 4

identifies this situation.

[0036] Since isolation of the supply voltage input E from the supply voltage output A means that all the other inventive apparatuses 1' and 1'' are nonlive, the devices 3' and 3'' in them then turn off. The connecting device 3 is in the form of a fast semiconductor switch, and hence the supply voltage continues to be applied to the supply voltage input A of the device 1, because the power supply unit for the supply voltage continues to be capable of operation.

[0037] As described above, the connection procedure now starts in the apparatus 1 as a result. Since no short circuit can now be detected at the supply voltage output A, the device 3 connects the supply voltage to the supply voltage output A. This supply voltage is then applied to the supply voltage input E' of the apparatus 1', which means that the turn-on procedure starts in the apparatus 1'. As a result of the device 4' impressing the current into the supply voltage output A', the short circuit in the apparatus 1'' is detected, which means that the connecting device 3' remains off. The turn-on operation has thus ended. In summary, this detects a short circuit arising during operation and initially disconnects the bus users connected to the supply voltage in series and then automatically connects them again one after the other, i.e. successively, up to the fault location.

[0038] This successive connection of the individual bus users by means of the inventive apparatuses is naturally also performed during normal "startup" of the control and data transmission installation.

[0039] In one embodiment (not shown) of the invention, the inventive apparatus has separate and electrically independent supply voltage inputs and outputs in each case for the logic and for the actuator equipment/sensor equipment of the associated module. Accordingly,

a bus user does not fail completely when, by way of example, the voltage supply for the actuator equipment/sensor equipment has failed, because the logic of the bus user continues to be capable of operation.

[0040] In another embodiment of the invention, the apparatus can additionally be connected to the automation bus and controlled by the system controller via an interface. By way of example, the controller can be used to control the connecting device when required, in order to connect the supply voltage input to the associated supply voltage output, or to isolate them. The inventive apparatus which has been connected only partially, i.e. its connecting device has not been controlled to connect the supply voltage input to the associated supply voltage output, outputs an error message to the controller via the automation bus. In this case, this error message comprises a data item which can be used to identify the apparatus concerned.

[0041] The inventive apparatus can, in principle, be used in all control and data transmission installations, that is to say, for example, in automation bus systems and, particularly, also in systems having a serial automation bus, such as a bus in accordance with EN 50254. According to requirements, each of the modules of the automation bus system which are connected to the supply voltage in series may in this case be assigned an inventive apparatus in the manner described. This applies not only to the entire system but also, in particular, to modules in an individual local bus section or a bus spur in the automation bus system. However, it is also possible for just one inventive apparatus to be assigned to a plurality of modules connected in succession in the automation bus system, so that the relevant modules connected to the supply voltage in series are all turned on and off together by the individual inventive apparatus.

[0042] In one embodiment (not shown), the inventive apparatus is set up to detect a ground fault. In this case, the differential current between plus and minus on the supply line is detected, and, in response to this differential current, the supply voltage input is isolated from the supply voltage output if a prescribed value is exceeded, so that the supply current for the components connected downstream of the supply voltage output is interrupted.

Abstract of the Disclosure

To provide an apparatus which can be used to turn on the series-connected modules in a control and data transmission installation reliably during operation without a short circuit presenting the risk that the entire installation or at least relatively large sections fail completely or cannot be started up, an apparatus is provided which has a supply voltage input and a supply voltage output associated with the latter, and contains a first device for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken and a second device for detecting an electrical load and/or for detecting the supply current. The inventive apparatus is connected to the supply voltage upstream or downstream of the associated module. Before the supply voltage input is connected to the associated supply voltage output, the supply voltage output is checked for an overload or a short circuit. If, by way of example, a short circuit is detected, then the supply voltage output is not connected to the supply voltage input, which means that overloading of the device providing the supply voltage can be reliably prevented. A plurality of modules which are connected in series and have respectively associated inventive apparatuses are connected successively, so that the series of modules can be started up at least up to the fault location.

ENGLISH TRANSLATION

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Phoenix Contact GmbH &Co

Circuit for turning on and operating units connected to their supply voltage in series in a control and data transmission installation

The invention relates to an apparatus for modules connected to the supply voltage in series in a control and data transmission installation, in particular for bus users in an automation bus system.

Modules in a control and data transmission installation, i.e. electrical components and units used in the design of an automation bus system, for example, are frequently connected to the supply voltage in series with one another. For this purpose, the units generally have a supply voltage input and a supply voltage output associated with the latter, this supply voltage output being connected to the supply voltage input of the next unit. If an individual unit in a number of units connected in series in this manner contains a short circuit, the supply voltage collapses generally for all the units, or the entire chain of units or modules cannot be started up, because the power supply unit reduces its output voltage on account of the short circuit, which means that the operation of individual units becomes an uncertainty. In addition, fault diagnosis is not possible, since none of the units are operational. The faulty unit can be ascertained only by removing all the units from the series circuit and starting them up individually.

However, such a practice is extremely labor-intensive and time-consuming for the operation of today's very complex

automation bus systems.

It is thus an object of the invention to provide an apparatus which can be used to turn on modules connected to their supply voltage in series in a control and data transmission installation reliably during operation without there being the risk that the entire installation or at least relatively large sections will fail completely.

This object is achieved by an apparatus having the features of claim 1, a control and data transmission installation having the features of claim 11, and with a method for connecting and operating such an apparatus as claimed in claim 13.

Accordingly, the inventive apparatus has at least one supply voltage input and at least one supply voltage output associated with the latter, and contains at least one first device for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken and a second device for detecting an electrical load and/or for detecting the supply current. In response to the detection of the electrical load and/or of the supply current, the supply voltage output can be connected to the supply voltage input. If, by way of example, a short circuit is detected at the supply voltage output, then the latter is not connected to the supply voltage input, which allows overloading of the device providing the supply voltage to be reliably prevented. If, on the other hand, no overload or short circuit is detected, then the supply voltage output is connected to the supply voltage input, and hence the module connected to the supply voltage output is connected to the supply voltage.

This also makes it possible to ensure that only the module or connecting line which has produced the short circuit or the overload is isolated from the supply voltage,

and also the modules connected downstream of the fault location. For this purpose, each of the modules connected to the supply voltage in series can have an inventive apparatus. This apparatus is connected to the supply voltage upstream or downstream of the respective module. This allows all modules which are in use and are connected to the supply voltage in series to be fitted with the inventive apparatus retrospectively. However, it is also possible for the inventive apparatus to be integrated directly in the module, for example in a bus user, which makes it possible for the inventive apparatus to be of compact design with a module in a control and data transmission installation.

In addition, the fault location in a module connected in series can easily be detected using the inventive apparatus, since the modules upstream of the fault location can still be kept in operation without the supply voltage collapsing.

Depending on requirements, the device used for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken may be a relay, a contactor, and/or a semiconductor switch. In this context, in its normal position, the switch used isolates the supply voltage input from the associated supply voltage output. In this case, a semiconductor switch has the advantage that it is maintenance free and can easily be controlled electrically or electronically.

If the inventive apparatus is set up for connection to the automation bus, the apparatus can also be controlled directly by the control system of the automation bus system. By way of example, this allows the control system to disconnect or connect a particular module directly using the supply voltage. In addition, data traffic between the control system and the inventive apparatus is also made possible.

To match the inventive apparatus to the respective requirements of the associated module, a memory device for storing the configuration of the devices of the apparatus may be included. By way of example, the configuration comprises a prescribed limit value for the supply current and/or for the electrical load, at which current or load the first device isolates the supply voltage output from the supply voltage input. This configuration may advantageously be carried out manually on the apparatus itself and/or via the automation bus. As already explained above, the apparatus can be integrated directly into the associated module, that is to say the module to be protected. This has the particular advantage that any bus interface which already exists on the module, for example the interface on a bus user in the automation bus system, can also be used for the inventive apparatus for connection to the bus.

Advantageously, the inventive apparatus may have separate supply voltage inputs and outputs in each case for the logic and for the actuator equipment/sensor equipment of the associated module, which makes it possible to separate the supply voltage for the logic circuits and for the actuator equipment/sensor equipment circuits of the associated module. Since the respective supply voltage outputs are operated by independent switches, failure of the actuator equipment/sensor equipment, for example, the relevant module can be kept in operation at least to a limited extent, for example for diagnostic purposes, using the logic circuits.

The inventive apparatus can be used in a wide variety of ways when designing an automation bus system, in particular when designing a serial automation bus system. To simplify the illustration, it is initially assumed that the inventive apparatus comprises its associated module itself. This is

equivalent to the inventive apparatus being regarded as integrated in the module.

As has been explained above and becomes clear below in the description of a few exemplary embodiments, the invention is not limited to this, however, since, in principle, any module connected to the supply voltage in series in a control and data transmission installation can have an inventive apparatus connected upstream or downstream of it. This allows any control and data transmission installation to be fitted with inventive apparatuses retrospectively by connecting an inventive apparatus to the supply voltage upstream or downstream of the respective module.

In the simplest case, a module comprising an inventive apparatus is electrically connected to its supply voltage in series with another module, the other module being connected downstream of the first-mentioned module. In the event of a fault, for example an overload or a short circuit in the module connected downstream, the supply voltage output of the first module, and hence also the supply voltage input of the module connected downstream, is isolated from the supply voltage by the inventive apparatus, so that the first module can remain in operation. In principle, any number of modules connected in series in an automation bus system can be protected from the supply voltage in this manner. Optimum protection by the inventive apparatus is provided if all the series-connected modules apart from the last one have an inventive apparatus. If, however, the inventive apparatus is connected in the module essentially upstream of the actual circuits, i.e. loads associated with the module, in which an overload or a short circuit can arise by way of preference, this last module should also be designed to be in series with the inventive apparatus, since a fault caused by the loads associated with the module is detected using the associated

inventive apparatus and is eliminated by isolation from the supply voltage, so that the modules connected upstream can all continue to operate.

If an overload occurs or a prescribed supply limit current is exceeded during operation, the inventive apparatus can isolate the supply voltage output from the associated supply voltage input, so that the modules or units connected upstream of this module can continue to operate. In this case, the device for detecting the supply current which is flowing may also be set up to detect a ground fault, for example using differential current formation.

In another embodiment of the invention, it is also possible for the supply voltage output to be connected to the supply voltage input with current limiting in the event of a fault, which means that, firstly, the subsequent modules can sometimes continue to operate at least to some extent, and, secondly, there is a risk that the modules connected upstream will fail on account of the supply voltage device for the series-onnected units being overloaded, because the supply voltage collapses. Such a fault situation covers the occurrence of an electrical overload but not of a "hard" short circuit, in which case the supply voltage would collapse despite current limiting.

The inventive apparatus also makes it possible to start up the series-onnected units or modules reliably. Depending on the embodiment of the invention, this can be done either automatically by the modules themselves using successive connection or via the bus under the control of the controller. The last connected module, whose inventive apparatus no longer connects the supply voltage input to the supply voltage output, or now connects them only with current limiting, is advantageously designed to output an error message. In this case, the fault is indicated on the relevant

module or the inventive apparatus, or an error message is sent to the controller via the bus. To provide for rapid identification of the fault location, the error message can comprise a data item for identifying the relevant module.

The invention is explained below by describing a few embodiments on the basis of the appended drawings, in which:

Fig.1 shows a schematic block diagram of modules electrically connected in series in an automation bus system, with associated inventive apparatuses in the quiescent state,

Fig.2 shows the apparatuses from figure 1 in the connecting phase,

Fig.3 shows a schematic block diagram of inventive apparatuses connected in electrical series, with integrated bus users, and

Fig.4 shows another schematic block diagram of a series circuit comprising inventive apparatuses with integrated bus users, the first apparatus having an additional device for detecting the supply current which is flowing.

Figure 1 shows a first embodiment of the inventive apparatus and the arrangement thereof in a control and data transmission installation, which is an automation bus system in the present case. Figure 1 shows a detail of the automation bus system, in which a plurality of bus users 2, 2', 2'' are connected to their supply voltage in series. Connected between these modules is a respective inventive apparatus 1, 1', 1''. Each bus user thus has an associated inventive apparatus. However, it is also possible for one inventive apparatus to be associated with a plurality of bus users connected to the supply voltage in series. In this case, an inventive apparatus is connected to the supply voltage at the start of the series circuit, and the bus users

connected subsequently in series are connected downstream of said apparatus.

Each of the inventive apparatuses comprises at least one supply voltage input E, E', E'' and an associated supply voltage output A, A', A''. Connected between the respective supply voltage input and output is a device 3, 3' 3'' which is able to connect the respective input to the associated output. In this context, the connecting device is controlled by a device 4, 4', 4'' for ascertaining at least one electrical variable at the supply voltage output.

According to the invention, the term supply voltage output denotes points on the supply voltage path which are disposed downstream of the connecting switch of the inventive apparatus. Accordingly, the term supply voltage input denotes points on the supply voltage path which are disposed upstream of the connecting switch of the inventive apparatus. Any connection devices for the supply voltage, for example for connecting the inventive apparatuses to routing conductors, are naturally also included in this definition.

One connecting devices (3, 3', 3'') is off if no supply voltage is applied to the supply voltage input of the inventive apparatus. If no supply voltage is applied to the first inventive apparatus 1, this is also the case on all the subsequent apparatuses 1' and 1'', and all the connecting devices 3, 3' and 3'' are off. In the embodiment shown, the connecting device 3, 3', 3'' is a semiconductor switch which is controlled by the device 4, 4', 4''. In the present case, this device 4, 4' or 4'' for ascertaining an electrical variable is a device which is designed to detect an electrical load at the supply voltage output. If the ascertained load exceeds a predetermined value, the respective connecting device 3, 3', 3'' remains off. In this case, the electrical loads associated with the inventive

apparatus 1, 1′ or 1′′ are connected at the supply voltage input E, E′ or E′′. To ascertain the electrical load at the supply voltage output, a low voltage is applied with current limiting to the supply voltage output, said voltage being so low that the subsequent module, i.e. the subsequent bus user, is not started up. The devices 4, 4′, 4′′ each have a current measuring apparatus which can be used to detect the current which is flowing, via the supply voltage output. If the ascertained flow of current exceeds a predetermined value, or even if the current limiting section responds, the supply voltage applied to the respective supply voltage input cannot be connected through to the associated supply voltage output, and the connecting device 3, 3′, 3′′, i.e. the respective semiconductor switch, remains off. This is a way of, firstly, reliably detecting an overload in the downstream supply voltage line or in one of the subsequent bus users, and also, by virtue of the semiconductor switch not turning on, of preventing the voltage supply from collapsing for all the series-connected bus users.

The way in which the inventive apparatus works is shown particularly when turning on the voltage supply for the bus section shown in figure 1. Figure 2 shows the final state for the case in which, when turning on, an illustrative overload exists and has been detected in third load 2′′ upstream of the third inventive apparatus 1′′. When turning on the voltage supply for the bus users 2, 2′ and 2′′ connected to the supply voltage in series, the supply voltage is first applied to the first bus user 2. The supply voltage is looped through this bus user 2 and is thus also applied to the inventive apparatus 1. The connecting device 3 of said apparatus is initially off, which means that there is no supply voltage at the supply voltage output A thereof, and accordingly the subsequent bus user 2′ is not connected. As

soon as the supply voltage is applied to the supply voltage input of the apparatus 1, a turn-on procedure stored in the apparatus is automatically performed. Within the scope of this, the electrical load present at the supply voltage output is first ascertained. This is done by applying a low voltage with current limiting to the supply voltage output A of the apparatus 1 and ascertaining the resultant flow of current using the device 4. In the embodiment described, the low voltage is just a few volts, e.g. approximately 3 volts, is thus far below the 24 volts required by the bus users, which means that the subsequent bus user 2' is not connected by applying the low voltage.

This measure is used to check the supply voltage line from the apparatus 1 to the bus user 2', and the supply voltage line from this bus user to the apparatus 1', and the bus user 2' itself. An existing electrical overload on account of a fault or even a short circuit within the areas cited is thus detected. In the present case, there is no electrical overload, which means that the device 3 for connecting the supply voltage input E to the associated supply voltage A is controlled such that the device 3 connects the output and the input to one another, with the result that the supply voltage is now fully present at the supply voltage output A and hence also on the second bus user 2', which means that the latter is also connected. As in the first bus user, the supply voltage is again looped through the bus user ånd is thus applied to the supply voltage input E' of the second inventive apparatus 1'. The turn-on procedure described is now performed in the second apparatus 2' too. In this case, however, an overload is detected in the third load 2''. In contrast to the sequence in the first inventive apparatus 1, the device 3' in the apparatus 1' is not controlled to connect the supply voltage input to the

associated supply voltage output, which means that the device 3' remains off. In this way, the inventive apparatus 1' prevents the overload from causing all the bus users among the bus users connected to the supply voltage in series to fail on account of the voltage supply unit being overloaded. Instead, only all the bus users which are situated upstream of the fault location in the series arrangement are connected. The apparatus 1' connected last, only partially, indicates the connection fault which has arisen using an indicator device (not shown in figure 2). According to the invention, an apparatus is connected only partially when, although the apparatus is being supplied with electricity and is in operation, the connecting device, in this case 3', is off. The manner described, i.e. using a fault indicator on the inventive apparatus which is not connected fully, makes it a simple matter to conduct a fault search even when there are a large number of modules, for example bus users, connected to the supply voltage in series.

To be able to match the inventive apparatus flexibly to the respective requirements, in particular to the supply currents based on the respective bus users, the apparatuses 1, 1' and 1'' each comprise a device for configuring the apparatus. The maximum electrical load permitted at the supply voltage output can be set manually, for example on the respective apparatuses, and this is used to stipulate the response of the connecting device 3, 3', 3''.

During operation, in the embodiment described, the device 4, 4' or 4'' is used to detect the supply current which is flowing, and if a predetermined value is exceeded, the device 3, 3' or 3'' is controlled to break the connection between the particular supply voltage input and the associated supply voltage output.

Another embodiment of the invention and its use in an automation bus system is shown in the schematic block diagram in figure 3. Again, as part of a control and data transmission installation, three inventive apparatuses 1, 1' and 1'', and also the associated bus users 2, 2' and 2'', are connected to the supply voltage in series. In this context, the bus user is integrated in the inventive apparatus in each case. In the embodiment shown, the respective bus users, i.e. the electrical loads associated with the bus user, are electrically connected downstream of the respective device for detecting a short circuit 4, 4', 4'', so that the inventive apparatus also checks the associated bus user for a short circuit. In the embodiment of the invention shown in figure 3, the device 4, 4' or 4'' is respectively designed to detect a short circuit. For this, it impresses a predetermined current into the respective supply voltage output when the connecting device 3, 3' or 3'' is off. A short circuit downstream of the supply voltage output results in a voltage drop at the supply voltage output, which is detected. In response to the ascertained short circuit in the downstream supply voltage line or the subsequent bus users, the connecting device remains off, so that there is ultimately no voltage at the supply voltage output of the respective apparatus. This is thus also true for the bus user contained in the inventive apparatus, which means that this bus user is not connected either. In another embodiment of the invention, however, not all of the devices or loads associated with the bus user are connected downstream of the respective connecting device 3, 3' or 3'', but rather at least some of them are connected upstream of it. Accordingly, if a supply voltage is applied to the supply voltage input, the bus user is connected at least partially. This applies in particular to a special embodiment of the invention in which

the bus user's bus connection is connected to its supply voltage upstream of the connecting device, which means that the bus connection is capable of operating when a voltage is applied to the supply voltage input. This bus connection of the bus user is also used for configuring the connecting device 3, 3' or 3''. For this, in the special embodiment, the inventive apparatus has a memory device for storing the configuration which has been set via the bus.

The method already described above for connecting the apparatuses or the bus users is also used in the case shown in figure 3 to detect a short circuit on the supply voltage connection between the second and third inventive apparatuses, and hence the connecting devices 3' and 3'' are not turned on, which means that the associated bus users 2' and 2'' are not connected. The first inventive apparatus 1, including the associated bus user 2, are both connected as prescribed, however.

In figure 4, the inventive apparatus 1 denotes another development of the inventive apparatus. The devices for ascertaining an electrical variable 4, 4', 4'' correspond to those in figure 3, i.e. a fault in the downstream supply voltage line or in the subsequent bus user is detected by impressing a current on the respective supply voltage output. In addition, the respective associated bus users 2 are integrated in the apparatuses, with the bus connection not being shown, as in figure 3. In contrast to the inventive apparatuses in figure 3, the first apparatus 1 also comprises an apparatus for detecting the supply current which is flowing. In this context, during fault-free operation, this supply current which is flowing comprises at least the supply current for the modules connected in series and the supply current for the associated inventive apparatuses. In the embodiment described, the device 5 is connected directly

downstream of the supply voltage input E of the apparatus 1, but may also be connected at the supply voltage output A of the apparatus, for example. The device measures the supply current flowing during operation of the series circuit (shown only in part) comprising inventive apparatuses with the associated bus users. Since the additional device is connected at the beginning of the series circuit, an electrical overload or a short circuit is thus reliably detected after all the series-connected apparatuses with associated modules have been connected. In this way, an increased current requirement for the series circuit during operation of the control and data transmission installation is reliably ascertained, and the necessary measures are taken.

The current detection device 5 is designed to control the connecting device 3. If an electrical overload or a short circuit arises during operation, the inventive apparatus 1 can thus interrupt the voltage supply for all the series-connected apparatuses with associated bus users by isolating the supply voltage input E from the supply voltage A as a result of an appropriate response from the device 3. The snapshot illustration shown in figure 4 identifies this situation.

Since isolation of the supply voltage input E from the supply voltage output A means that all the other inventive apparatuses 1' and 1'' are nonlive, the devices 3' and 3'' in them then turn off. The connecting device 3 is in the form of a fast semiconductor switch, and hence the supply voltage continues to be applied to the supply voltage input A of the device 1, because the power supply unit for the supply voltage continues to be capable of operation.

As described above, the connection procedure now starts in the apparatus 1 as a result. Since no short circuit can

now be detected at the supply voltage output A, the device 3 connects the supply voltage to the supply voltage output A. This supply voltage is then applied to the supply voltage input E' of the apparatus 1', which means that the turn-on procedure starts in the apparatus 1'. As a result of the device 4' impressing the current into the supply voltage output A', the short circuit in the apparatus 1'' is detected, which means that the connecting device 3' remains off. The turn-on operation has thus ended. In summary, this detects a short circuit arising during operation and initially disconnects the bus users connected to the supply voltage in series and then automatically connects them again one after the other, i.e. successively, up to the fault location.

This successive connection of the individual bus users by means of the inventive apparatuses is naturally also performed during normal "startup" of the control and data transmission installation.

In one embodiment (not shown) of the invention, the inventive apparatus has separate and electrically independent supply voltage inputs and outputs in each case for the logic and for the actuator equipment/sensor equipment of the associated module. Accordingly, a bus user does not fail completely when, by way of example, the voltage supply for the actuator equipment/sensor equipment has failed, because the logic of the bus user continues to be capable of operation.

In another embodiment of the invention, the apparatus can additionally be connected to the automation bus and controlled by the system controller via an interface. By way of example, the controller can be used to control the connecting device when required, in order to connect the supply voltage input to the associated supply voltage output,

or to isolate them. The inventive apparatus which has been connected only partially, i.e. its connecting device has not been controlled to connect the supply voltage input to the associated supply voltage output, outputs an error message to the controller via the automation bus. In this case, this error message comprises a data item which can be used to identify the apparatus concerned.

The inventive apparatus can, in principle, be used in all control and data transmission installations, that is to say, for example, in automation bus systems and, particularly, also in systems having a serial automation bus, such as a bus in accordance with EN 50254. According to requirements, each of the modules of the automation bus system which are connected to the supply voltage in series may in this case be assigned an inventive apparatus in the manner described. This applies not only to the entire system but also, in particular, to modules in an individual local bus section or a bus spur in the automation bus system. However, it is also possible for just one inventive apparatus to be assigned to a plurality of modules connected in succession in the automation bus system, so that the relevant modules connected to the supply voltage in series are all turned on and off together by the individual inventive apparatus.

In one embodiment (not shown), the inventive apparatus is set up to detect a ground fault. In this case, the differential current between plus and minus on the supply line is detected, and, in response to this differential current, the supply voltage input is isolated from the supply voltage output if a prescribed value is exceeded, so that the supply current for the components connected downstream of the supply voltage output is interrupted.

Claims

1. An apparatus (1, 1', 1'') for modules (2, 2', 2'') connected to the supply voltage in series in a control and data transmission installation, in particular for bus users in an automation bus system, comprising

- at least one supply voltage input (E, E', E'') and an associated supply voltage output (A, A', A''), and

- a device (3, 3', 3'') for connecting the supply voltage input to the supply voltage output in response to a

- device (4, 4', 4'') for ascertaining at least one electrical variable at the supply voltage output.

2. The apparatus (1, 1', 1'') as claimed in claim 1, characterized in that

the device (4, 4', 4'') is set up to ascertain at least one electrical variable for detecting an electrical load and/or a short circuit.

3. The apparatus as claimed in claim 1 or 2, characterized in that

the apparatus (1, 1', 1'') is designed to detect the supply current which is flowing.

4. The apparatus as claimed in claim 1, 2 or 3, characterized in that

the connecting device (3, 3', 3'') comprises a relay, a contactor and/or a semiconductor switch.

5. The apparatus as claimed in one of the preceding

claims 1 to 4,

characterized in that

the apparatus (1, 1', 1') has a connection device for connection to the automation bus.

6. The apparatus as claimed in one of claims 1 to 5, characterized in that

the apparatus (1, 1', 1'') is designed to be configurable manually and/or via the automation bus and has at least one memory device for storing the configuration.

7. The apparatus as claimed in one of claims 1 to 6, characterized in that

the apparatus has separate and electrically independent supply voltage inputs and outputs in each case for the logic and for the actuator equipment/sensor equipment of the associated module.

8. The apparatus as claimed in one of claims 1 to 7, characterized in that

the apparatus (1, 1', 1'') itself comprises its associated module (2, 2', 2'') in a control and data transmission installation, in particular a bus user in an automation bus system.

9. The apparatus as claimed in claim 8, characterized in that

the module (2, 2', 2'') is connected to its supply voltage essentially downstream of the device (3, 3', 3'') for connecting the supply voltage input to the supply voltage output.

10. The apparatus as claimed in one of claims 1 to 9, characterized in that
apparatus is set up to detect a ground fault.

11. A control and data transmission installation, in particular a system which has a serial automation bus and comprises at least one apparatus (1, 1', 1'') as claimed in one of claims 1 to 9, having at least one associated module (2, 2', 2''), the module being electrically connected to the supply voltage in series with at least one other module, and the apparatus being connected upstream of the other module.

12. The control and data transmission installation as claimed in claim 11, characterized in that the automation bus is a bus in accordance with EN 50254, and at least the first module (2) of the modules (2, 2', 2'') connected to the supply voltage in series has an associated apparatus as claimed in one of claims 1 to 10 in a local bus section or a bus spur.

13. A method for connecting and operating an apparatus as claimed in one of claims 1 to 10, comprising the following steps:

- a) a supply voltage is applied to the supply voltage input of the apparatus (1, 1', 1''),
- b) an electrical load and/or a short circuit at the supply voltage output (A, A', A'') is detected,
- c) the device (3, 3',3'') for connecting the supply voltage input (E, E', E'') to the associated supply voltage output (A, A', A'') is controlled in response to the detected electrical load and/or of a

short circuit.

14. The method as claimed in claim 13, characterized in that method step c) comprises the following steps:

- c1) the detected load is compared with a predetermined value, and

- c2) the supply voltage input (E, E', E'') is connected to the associated supply voltage output (A, A', A'') if the detected load does not exceed the predetermined value.

15. The method as claimed in claim 13, characterized in that method step c) comprises the following step:

- the supply voltage input (E, E', E'') is connected to the associated supply voltage output (A, A', A'') if no short circuit has been detected.

16. The method for connecting and operating an apparatus as claimed in one of claims 3 to 10 as claimed in one of method claims 13 to 15, comprising the following additional steps:

- the supply current which is flowing is detected, and

- the connection between the supply voltage input (E, E', E'') and the associated supply voltage output (A, A'; A'') is broken if the detected supply current exceeds a predetermined value.

17. A method for connecting and operating series-connected apparatuses in a control and data transmission installation as claimed in one of claims 11 or 12,

characterized in that,

starting with the first apparatus (1), the apparatuses (1', 1', 1'') are successively connected, in each case as claimed in one of method claims 12 to 15.

18. The method as claimed in claim 17, characterized in that

connection takes place automatically or is controlled via the automation bus.

19. The method as claimed in one of claims 17 or 18, characterized in that

an apparatus (1, 1', 1'') connected only partially outputs an error message to indicate a short circuit or an overload at its voltage supply output, the error message being output to an indicator device and/or via the automation bus in order to control the automation bus system.

20. The method as claimed in claim 19, characterized in that

the error message output via the automation bus comprises at least one data item for identifying the apparatus (1, 1', 1'') connected only partially.

Abstract

The invention relates to an apparatus for modules connected to the supply voltage in series in a control and data transmission installation for turning on and operating the modules.

To provide an apparatus which can be used to turn on the series-connected modules in a control and data transmission installation reliably during operation without a short circuit presenting the risk that the entire installation or at least relatively large sections fail completely or cannot be started up, an apparatus is provided which has a supply voltage input and a supply voltage output associated with the latter, and contains a first device for connecting the supply voltage input to the associated supply voltage output such that the connection can be broken and a second device for detecting an electrical load and/or for detecting the supply current. The inventive apparatus is connected to the supply voltage upstream or downstream of the associated module. Before the supply voltage input is connected to the associated supply voltage output, the supply voltage output is checked for an overload or a short circuit. If, by way of example, a short circuit is detected, then the supply voltage output is not connected to the supply voltage input, which means that overloading of the device providing the supply voltage can be reliably prevented.

A plurality of modules which are connected in series and have respectively associated inventive apparatuses are connected successively, so that the series of modules can be started up at least up to the fault location.

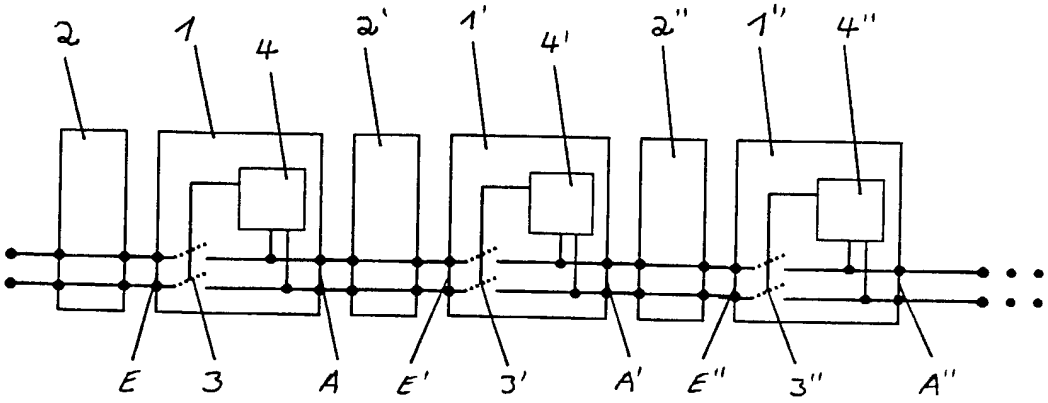

Fig. 1

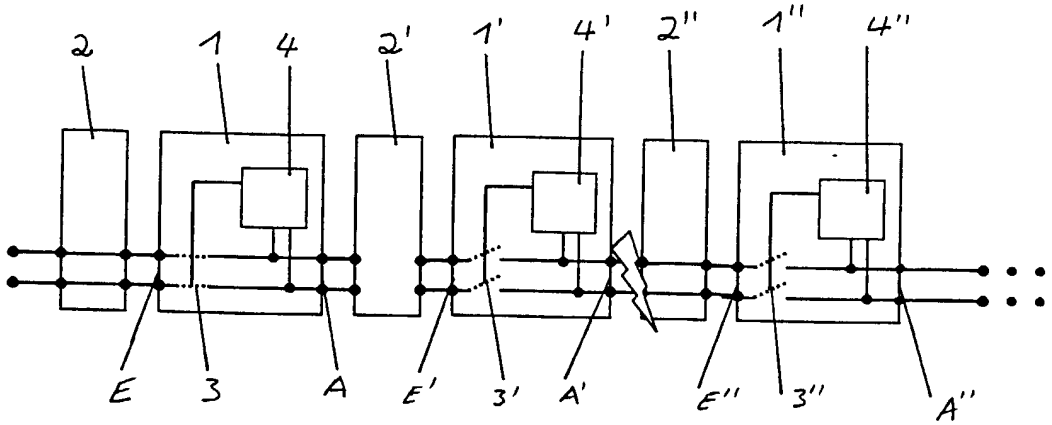

Fig. 2

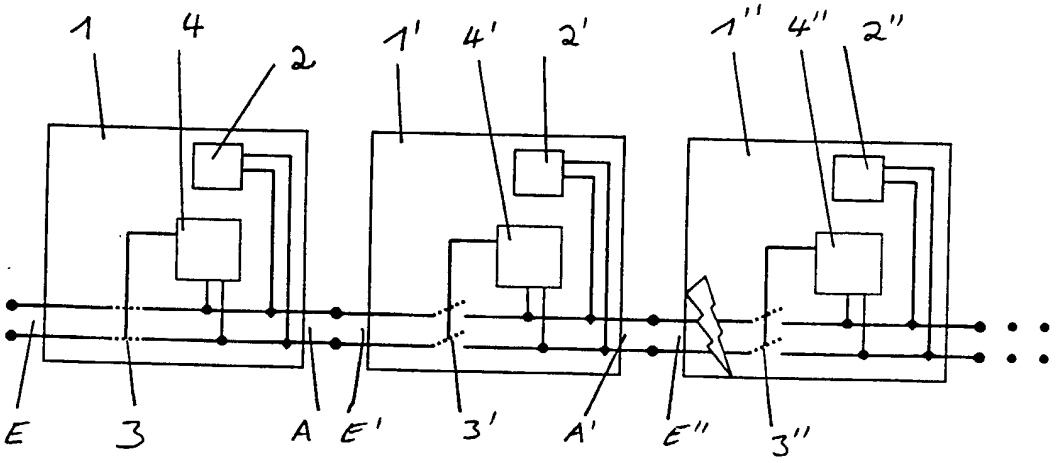

Fig. 3

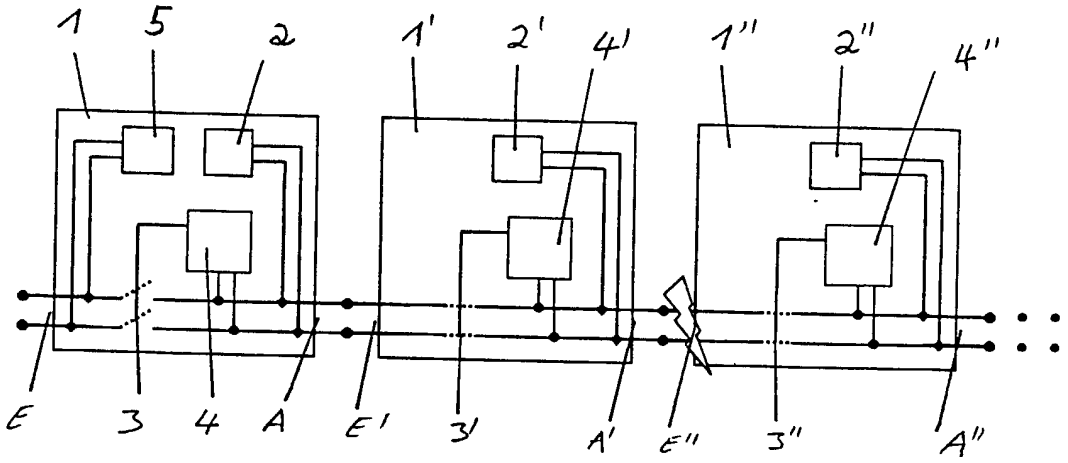

Fig. 4

Docket No.
(H)01PH0405USP

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Circuit for switching on and operating units connected in series with regard to their power supply voltage in a control and data transmission system

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on **June 27, 2000** as United States Application No. or PCT International Application Number **PCT/DE00/02017**

and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
199 29 641.3	**Germany**	**28/06/1999**	☐
(Number)	(Country)	(Day/Month/Year Filed)	
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Full name of sixth inventor, if any

Sixth inventor's signature Date

Residence

Citizenship

Post Office Address